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Influence of different approaches and forms of fertilizers on hybrid maize yield, uptake and nutrient balance in Alfisols of eastern dry zone of Karnataka

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Summary

A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, GKVK, Bengaluru to study the influence of different forms of fertilizers through different approaches on maize yield, uptake and nutrient balance on soils of Kandic Paleustalf. The results revealed that application of soluble fertilizers through STCR (90q ha^{-1}) with 3 splits and 3 sprays of 19:19:19 recorded higher grain (98.22 q ha^{-1}) and stover yield (130.96 q ha^{-1}). Similarly, significantly higher nutrient uptake was observed where soluble fertilizers were applied as compared to conventional fertilizers applied either through RDF (Recommended Dose of Fertilizer) or STCR approach. These results clearly indicate that application of soluble fertilizers through STCR approach would help to get higher yield and higher nutrient uptake in maize crop.

Key words : Alfisol, Maize, Soluble fertilizers, RDF, STCR

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Introduction

Maize (*Zea mays* L.) is one of the important staple food crop of the world and ranks next to wheat and rice. In the world, it is grown in an area of 145 m ha with an annual production of 695 m t with a productivity of 4820 kg ha^{-1}. In India maize ranks fourth after rice, wheat and sorghum and it is cultivated in an area of 9.43 m ha with a production of 24.35 m t with a productivity of 2583 kg ha^{-1} (Anonymous, 2014). In Karnataka, maize is grown in an area of 1.2 m ha with a production of 3.6 m t with a productivity of 3000 kg ha^{-1} (Anonymous, 2011).

Soil test calibration is intended to establish a relationship between the levels of soil nutrients determined in the laboratory and response of crops to applied fertilizer nutrients in the field permits balanced fertilization through right kind and amount of fertilizers. In this regard, STCR targeted yield approach has been found to be beneficial which recommends balanced fertilization considering the soil available nutrient status and crop needs (Ramamoorthy *et al.,* 1967). Water

soluble fertilizers are those fertilizers with different grades of NPK containing fertilizers which are completely soluble in water and characterised by high purity and can be applied in lower doses to get higher benefits. For efficient use of nutrients for maize production, it is an important management strategy for increasing crop yield and improving nutrient use efficiency (NUE) which can be practiced by split application of fertilizer nutrients (Tadesse *et al.*, 2013). Foliar application of fertilizer nutrients is a widely adopted strategy in modern crop management where it is used to ensure optimal crop performance by enhancing crop growth at certain growth stage, correcting the nutrient deficiency in crop and enhancing crop tolerance to adverse conditions for crop growth (Chaurasia *et al.*, 2006). In this context, the present study was carried out to know the influence of different approaches, forms and methods of fertilizer applicationon crop yield, nutrient uptake, soil properties and nutrient balance by maize crop.

Resource and Research Methods

A field experiment was conducted during *Kharif* 2014 at Zonal Agricultural Research Station, UAS, GKVK, Bengaluru, Karnataka to study the influence of different approaches, forms and methods of fertilizer application on crop yield, nutrient uptake, soil properties and nutrient balanceby maize (*Zea mays* L.) crop. The soil of the experimental site was loamy sand in texture classified as Kandic Paleustalf which was slightly acidic (pH 5.98), with low salt content (0.059 dSm^{-1}) and low organic carbon content (0.39%). The available nitrogen (232.40 kg ha^{-1}) was low and available phosphorus (256.20 kg ha^{-1}) was high, available potassium content (188.40 kg ha^{-1}) was medium.The experiment was laid out in a Randomized Complete Block Design with ten treatments replicated thrice. The treatment combination include, T_1: 100 per cent RDF through conventional fertilizers, T_2: 100 per cent STCR dose through conventional fertilizer,T_3: 100 per cent STCR dose through soluble fertilizer, T_4: 50 per cent STCR dose through soluble fertilizer, T_5:100 per cent STCR dose through soluble fertilizer with 3 splits, T_6: 50 per cent STCR dose through soluble fertilizer with 3 splits T_7: 100 per cent STCR dose through soluble fertilizer with 3 sprays of 1 per cent 19 all, T_8: 50 per cent STCR dose through soluble fertilizer with 3 sprays, T_9: 100 per cent STCR dose through soluble fertilizer with 3 splits and 3 sprays and $T_{10:}$50 per cent STCR dose through soluble fertilizer with 3 splits and 3 sprays.

For all the treatments 10t FYM ha^{-1} and 10 kg $ZnSO_4$ ha^{-1} were applied. With respect to NPK, different forms of fertilizers and doses were applied as per the treatments. Three splits was done at basal, 30 and 50 DAS for NPK, whereas foliar spray was done at 20, 40 and 60 DAS for 19:19:19 @ 1% concentration. Water soluble fertilizers used were calcium nitrate (15.5 % N and 18.8 % Ca), 00:00:50 and 19:19:19 grades. The following STCR targeted yield equation developed for hybrid maize by AICRP on STCR, Bengaluru centre (Anonymous, 2007) was used for calculating the NPK fertilizer nutrient requirements based on the target fixed (90 q ha^{-1}).

F.N.= 3.84 T – 0.42 S.N ($KMnO_4$-N)

F.P_2O_5= 1.57 T – 1.18 S.P_2O_5 (Bray's)

F.K_2O.= 1.15 T – 0.11 S. K_2O (Am. Ac.)

where,

Table A: Quantity of nutrients applied per hectare through different approaches as per the treatments

Treatments	N	P_2O_5	K_2O
		(kg ha^{-1})	
T_1: Control (RDF – CF)	150.00	75.00	40.00
T_2 : 100% STCR dose- CF*	198.05	9.86	33.80
T_3: 100% STCR dose – SF**	204.05	0.00	36.05
T_4 : 50% STCR dose – SF	102.24	0.00	18.00
T_5 : 100% STCR dose - SF - 3 splits	200.08	0.00	34.36
T_6: 50% STCR dose - SF - 3 splits	98.87	0.00	16.28
T_7 : 100% STCR dose- SF - 3 sprays	206.67	0.00	30.98
T_8: 50% STCR dose - SF - 3 sprays	103.10	0.00	16.44
T_9: 100% STCR dose- SF - 3 splits and 3 sprays	205.57	0.00	33.10
T_{10}: 50% STCR dose - SF - 3 splits and 3 sprays	104.36	0.00	17.50

*CF-Conventional fertilizers **SF-Soluble fertilizers

T = Targeted yield (90 q ha^{-1}), F.N. = Nitrogen supplied through fertilizer (kg ha^{-1}), F.P_2O_5 = Phosphorus supplied through fertilizer (kg ha^{-1}), F.K_2O = Potassium supplied through fertilizer (kg ha^{-1}), S.N., S.P_2O_5 and S.K_2O. the initial available N, P_2O_5 and K_2O kg ha^{-1}, respectively (Table A).

At harvest, representative plant samples were collected from the test crop, washed thoroughly with running water followed by double distilled water. The plant samples were then dried to attain constant weight, ground and analysed for NPK nutrients in grain and stover samples as described by Tandon (1993).

The uptake of these nutrients by maize crop was computed by using the following formula :

$$\textbf{Uptake (kg ha}^{-1}\textbf{)} = \frac{\textbf{Nutrient concentration (\%) x Biomass (kg ha}^{-1}\textbf{)}}{\textbf{100}}$$

At harvest of maize crop, soil samples collected from different treatments were processed and analyzed for available nitrogen (Subbaiah and Asija, 1956), available phosphorus (Jackson, 1973), available potassium (Page *et al.*, 1982). At harvest observations on yield parameters were recorded and grain and stover yields were expressed in quintal per hectare. Five plants grain and stover samples from each plot were collected separately at harvest.

Balance sheet of nitrogen, phosphorus and potassium were worked out by considering the status of available N, P_2O_5 and K_2O in the initial soil sample, amount of N, P_2O_5 and K_2O added through fertilizer and uptake of N, P_2O_5 and K_2O. Expected balance of N, P_2O_5 and K_2O were calculated by subtracting N, P_2O_5 and K_2O taken up by the crop from total N, P_2O_5 and K_2O. Net gain or loss of nutrient was worked out by subtracting actual balance from the expected balance of the nutrients.

All these data *viz*., grain yield, stover yield, nutrient uptake, nutrient balance sheet and soil data were statistically analysed by adopting standard procedure outlined by Gomez and Gomez (1984).

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect on grain and stover yield :

Application of soluble fertilizers based on STCR approach at three splits along with three sprays of 19:19:19 @ 1% concentration (T_9) resulted in highest grain (98.22 q ha^{-1}) and stover yield (130.96 q ha^{-1}) compared to all other treatments (Table 1). This increased yield might be due to easy solubility and uniform distribution of nutrients in root zone leading to sufficient availability of nutrients for uptake by the crop (Hebbar *et al*., 2004). Similarly, application of required quantity of nutrients through soluble fertilizers with three splits, helped in efficient use of nutrients without fixation or leaching losses (Tadesse *et al*., 2013). In addition spraying with 19:19:19 at three stages of crop growth helped in better translocation and uptake of these nutrients without any losses (Chaurasia *et al.*, 2006 and Premsekhar and Rajashree, 2009).

Table 1 : Grain and stover yield of maize as influenced by different approaches and different forms of fertilizer application

Treatments	Grain yield	Stover yield
	(q ha^{-1})	
T_1: Control (RDF - CF)	82.56	84.37
T_2 : 100% STCR dose- CF	90.48	99.21
T_3: 100% STCR dose – SF	92.59	112.29
T_4 : 50% STCR dose – SF	89.97	90.41
T_5 : 100% STCR dose - SF - 3 splits	97.59	123.24
T_6: 50% STCR dose - SF - 3 splits	92.26	110.76
T_7 : 100% STCR dose- SF - 3 sprays	96.83	123.00
T_8: 50% STCR dose - SF - 3 sprays	94.34	115.54
T_9: 100% STCR dose- SF - 3 splits and 3 sprays	98.22	130.96
T_{10}: 50% STCR dose - SF - 3 splits and 3 sprays	94.87	119.63
S.E. ±	1.67	3.56
C.D. (P=0.05)	4.96	10.57

Effect on soil major nutrients :

The data presented in Table 2 indicated the available NPK status of soil as influenced by different approaches and different forms of fertilizer application. Higher amount of available nitrogen was noticed in treatment receiving (224.75 kg N ha^{-1}) 100 per cent STCR dose applied through soluble fertilizers with three splits along with three sprays of 19 all and lower available N was recorded in T_4, where 50 per cent STCR dose was applied through soluble fertilizers (194.51 kg N ha^{-1}). Available nitrogen content of soil varied between the treatments because of the varied levels of N application from treatments to treatments adopting STCR approach, which might be the reason for variation in available nitrogen content (Praveena Katharine *et al*., 2014).

The available phosphorus content of soil did not show any significant difference between treatments (Table 2). Higher available phosphorus (280.03 kg P_2O_5 ha^{-1}) was recorded in (T_5) treatment receiving 100 per cent STCR dose through soluble fertilizers in three splits compared to all other treatments. This non-significant variation in available phosphorus might be due to high build of available P in the whole plot due to continuous fertilization (Atheefa, 2007).

Significantly higher available potassium (171.20 kg K_2O ha^{-1}) was recorded in the treatment (T_7) which received 100 per cent STCR dose through soluble fertilizers with three sprays of 19:19:19 @ 1% concentration and lower (123.73 kg K_2O ha^{-1}) value was recorded in T_4, where 50 per cent STCR dose was applied through soluble fertilizers (Table 2). The increased potassium might be due to addition of FYM to soil which increased the nutrient availability to crop due to their direct addition, particularly the soluble fertilizers and also due to chelation of these nutrients by FYM, there by ensuring their availability for longer period. Similar results were observed by Elayarajan *et al*. (2015); Manasa (2013) and Shashi (2003).

Effect on uptake of major nutrients :

Higher total uptake of nitrogen (269.90 kg N ha^{-1}) was recorded in treatment (T_9) receiving 100 per cent STCR dose through soluble fertilizers with three splits along with three sprays of 19:19:19 compared to all other treatments (Table 3). This increased uptake of nitrogen might be due to higher grain and stover yield in this treatment. The higher uptake of nitrogen might also be due to addition of higher nitrogen based on STCR approach (Santhosha, 2013). Specially through split application of nutrients in the present study, which was supported by the study of Tadesse *et al*. (2013), who found greater N uptake on splitting due to reduction in N losses *i.e.*, denitrification, immobilization and leaching. The higher N uptake was also caused due to foliar application of 19:19:19 which helped in better translocation of nutrients resulting in increase in the nitrogen uptake (Saravanan *et al*., 2013).

Higher total uptake of phosphorus by maize grain (61.30 kg P ha^{-1}) was higher in treatment (T_5) receiving 100 per cent STCR dose applied through soluble

Table 2 : Effect of different approaches and different forms of fertilizer application on available major nutrient status of soil after harvest of maize crop

Treatments	N	P_2O_5	K_2O
	(kg ha^{-1})		
T_1: Control (RDF - CF)	195.17	218.12	133.60
T_2 : 100% STCR dose- CF	201.23	225.31	142.80
T_3: 100% STCR dose – SF	202.35	220.82	137.07
T_4 : 50% STCR dose – SF	194.51	216.42	123.73
T_5 : 100% STCR dose - SF - 3 splits	202.72	280.03	162.53
T_6: 50% STCR dose - SF - 3 splits	194.88	239.99	153.60
T_7 : 100% STCR dose- SF - 3 sprays	216.91	263.84	171.20
T_8: 50% STCR dose - SF - 3 sprays	208.45	267.12	147.60
T_9: 100% STCR dose- SF - 3 splits and 3 sprays	224.75	268.16	163.33
T_{10}: 50% STCR dose - SF - 3 splits and 3 sprays	217.65	264.05	144.93
S.E. ±	3.82	25.26	11.99
C.D. (P=0.05)	11.35	NS*	35.63

*NS= Non-significant

fertilizers in three splits along with three sprays (Table 3). Increased uptake of phosphorus might be due to higher grain and stover yield and in the present study higher available phosphorus also influenced the higher 'P' uptake. Similarly, wherever 'P' was sprayed through 19:19:19, the 'P' uptake increased. This might be due to its easy availability and absorption when applied as foliar spray without spending much energy for their transport and without any loss (Chaurasia *et al.*, 2006).

Higher total uptake of potassium (188.67 kg ha^{-1}) was recorded in treatment (T_9) receiving 100 per cent STCR dose applied through soluble fertilizers in three splits along with three sprays (Table 3). This increased uptake could be due to better availability and uptake of nutrients as a result of splits and sprays in root zone coupled with better root activity (Hebbar *et al*., 2004).

Effect on nutrient balance in soil :

Higher actual balance of available nutrients was noticed in treatment receiving 100 per cent STCR dose applied through (T_9) soluble fertilizers (224.75 kg N ha^{-1}) in three splits along with three sprays (Table 4). Higher actual balance might be due to efficient use of nitrogen when applied as soluble fertilizer due to reduced leaching and volatilization losses as these nutrients are applied in three splits and three sprays which enhanced the actual balance even though crop uptake was higher. However, overall gain was higher when fertilizers were applied at 50 per cent STCR dose through soluble fertilizers in three splits along with three sprays of 19:19:19 @ 1% concentration (Omokanye *et al*., 2011).

Balance of phosphorus revealed that uptake of phosphorus ranged from 90.93 to 140.25 kg P_2O_5 ha^{-1} from initial to harvest which was derived from soil pool and fertilizers added to maize crop (Table 4). The actual balance of phosphorus was higher (280.03 kg P_2O_5 ha^{-1}) in treatment receiving (T_5) 100 per cent STCR dose applied through soluble fertilizers in three splits compared to all other treatments and higher positive balance (130.95) was noticed in (T_7) 100 per cent STCR dose applied through soluble fertilizers along with three sprays of 19:19:19. The higher positive balance might be due to higher level of soil available phosphorus content in the whole plot (Santhosha, 2013).

The actual balance of potassium was higher in (T_7) treatment receiving 100 per cent STCR dose applied through soluble fertilizers along with three sprays of 19:19:19 (171.20 kg K_2O ha^{-1}) compared to other treatments (Table 4). This higher actual balance might be due to incorporation of FYM along with fertilizer K which increased the cumulative non-exchangeable K release and maintained greater amounts of potassium in solution and on exchange sites by re-establishing the equilibrium among the forms of potassium. In the present study, FYM was applied to all plots; hence, all the treatments recorded positive balance (Singh *et al.*, 2002).

From the present study, it is concluded that application of soluble fertilizers through STCR approach with three splits at basal, 30 and 50 DAS and three sprays of 19:19:19 @ 1% concentration at 20, 40 and 60 DAS

Table 3: Uptake of major nutrients by grain and stover of maize crop as influenced by different approaches and different forms of fertilizers application

Treatments	N			P			K		
	Grain	Stover	Total	Grain	Stover	Total	Grain	Stover	Total
	(kg ha^{-1})								
T_1: Control (RDF - CF)	130.53	52.72	183.25	22.38	17.31	39.69	42.03	88.15	130.18
T_2 : 100% STCR dose- CF	143.13	62.05	205.18	24.75	20.10	44.86	46.35	104.90	151.25
T_3: 100% STCR dose – SF	149.07	72.67	221.74	24.90	23.31	48.21	48.22	116.25	164.47
T_4 : 50% STCR dose – SF	144.84	57.12	201.96	25.00	18.14	43.14	46.52	91.10	137.61
T_5 : 100% STCR dose - SF - 3 splits	163.43	80.60	244.03	30.09	25.03	55.12	51.58	134.84	186.42
T_6: 50% STCR dose - SF - 3 splits	153.33	70.03	223.36	26.20	19.76	45.96	46.91	110.94	157.85
T_7 : 100% STCR - SF - 3 sprays	168.63	88.39	257.02	29.65	28.08	57.74	52.93	126.72	179.65
T_8: 50% STCR dose - SF - 3 sprays	161.14	82.71	243.86	28.82	27.64	56.46	46.76	120.08	166.84
T_9: 100% STCR dose- SF - 3 splits and 3 sprays	176.13	93.78	269.90	31.86	29.44	61.30	51.03	137.64	188.67
T_{10}: 50% STCR dose - SF - 3 splits and 3 sprays	168.59	81.12	249.71	28.45	26.92	55.37	48.69	122.33	171.02
S.E. ±	4.91	3.91	6.85	1.47	1.70	2.37	2.22	7.92	7.71
C.D. (P=0.05)	14.59	11.63	20.34	4.36	5.06	7.03	6.61	23.52	22.91

Table 4: Balance for N, P_2O_5 and K_2O (kg ha^{-1}) in soil as influenced by different approaches and different forms of fertilizer application on maize crop

Treatments	Initial available N, P_2O_5 and K_2O	Addition through fertilizer	Total	Removal by crops	Expected balance	Actual balance	Net loss (-) or gain (+)
*(1)	*(2)	*(3)	*(4=2+3)	*(5)	*(6=4-5)	*(7)	*(8=7-6)
Nitrogen							
T_1	226.99	150.00	376.99	183.27	193.72	195.17	1.46
T_2	244.16	198.05	442.21	205.20	237.01	201.23	-35.78
T_3	229.97	204.05	434.03	221.74	212.28	202.35	-9.94
T_4	228.48	102.24	330.72	201.97	128.75	194.51	65.76
T_5	239.31	200.08	439.39	244.00	195.39	202.72	7.33
T_6	244.91	98.87	343.78	223.30	120.48	194.88	74.40
T_7	223.63	206.67	430.30	256.94	173.36	216.91	43.55
T_8	224.75	103.10	327.85	243.85	84.00	208.45	124.45
T_9	226.24	205.57	431.81	269.79	162.02	224.75	62.72
T_{10}	218.77	104.36	323.13	249.36	73.77	217.65	143.89
Phosphorus							
T_1	221.66	75.00	296.66	90.93	205.73	218.12	12.39
T_2	272.33	9.86	282.19	102.70	179.49	225.31	45.82
T_3	279.19	0.00	279.19	110.44	168.75	220.82	52.07
T_4	267.98	0.00	267.98	98.78	169.20	216.42	47.22
T_5	323.52	0.00	323.52	126.02	197.50	280.03	82.53
T_6	260.79	0.00	260.79	105.33	155.46	239.99	84.53
T_7	265.09	0.00	265.09	132.21	132.88	263.84	130.95
T_8	369.07	0.00	369.07	129.38	239.69	267.12	27.43
T_9	279.88	0.00	279.88	140.25	139.63	268.16	128.53
T_{10}	325.28	0.00	325.28	126.77	198.51	264.05	65.54
Potassium							
T_1	174.40	40.00	214.40	156.22	58.18	133.60	75.42
T_2	197.20	33.80	231.00	181.53	49.47	142.80	93.33
T_3	176.80	36.05	212.85	197.37	15.48	137.07	121.59
T_4	177.20	18.00	195.20	165.09	30.11	123.73	93.62
T_5	191.60	34.36	225.96	223.57	2.39	162.53	160.14
T_6	208.80	16.28	225.08	189.40	35.68	153.60	117.92
T_7	222.80	30.98	253.78	215.48	38.30	171.20	132.90
T_8	205.60	16.44	222.04	200.14	21.90	147.60	125.70
T_9	203.60	33.10	236.70	226.56	10.14	163.33	153.19
T_{10}	186.40	17.50	203.90	205.14	-1.25	144.93	146.18

*Indicates column number

has helped in efficient uptake of nutrients which influenced in higher grain and stover yield of hybrid maize.

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